

**TUNGSTEN ALLOY HIGH TEMPERATURE
TOOL MATERIALS**

Inventor(s)

**Evan K. Ohriner
304 Saint Andrews Drive
Knoxville, Tennessee**

**Stan A. David
12012 Broadwood Drive
Knoxville, Tennessee 37922**

Docket No. 1318

TUNGSTEN ALLOY HIGH TEMPERATURE TOOL MATERIALS

[0001]. The United States Government has rights in this invention pursuant to contract no. DE-AC05-00OR22725 between the United States Department of Energy and UT-Battelle, LLC.

[0002]. **FIELD OF THE INVENTION**

[0003]. The present invention relates to tungsten-based alloy tool materials, and more particularly to tungsten-based alloy tool materials that contain rhenium, hafnium, and carbon.

[0004]. **BACKGROUND OF THE INVENTION**

[0005]. Currently available tooling materials, for example, rotary parts and friction stir welding tools for joining ferrous and high-temperature materials, do not generally provide to a sufficient degree the combination of wear resistance and toughness that is necessary for applications at temperatures above 800 °C. Most known metallic tool materials have insufficient high-temperature hardness, and tend to deform under stress, strain and/or wear at high temperatures. Moreover, most known ceramic tool materials have insufficient toughness for many applications, and tend to crack or fracture under stress and/or strain.

[0006]. **OBJECTS OF THE INVENTION**

[0007]. Accordingly, objects of the present invention include: provision of a tungsten alloy tool material that can withstand application temperatures above 800 °C. Further and other objects of the present invention will become apparent from the description contained herein.

[0008]. **SUMMARY OF THE INVENTION**

[0009]. In accordance with one aspect of the present invention, the foregoing and other objects are achieved by a tool made from an alloy that includes, in weight %, 3% to 27% rhenium, 0.03% to 3% hafnium, and 0.002% to 0.2% carbon, balance tungsten.

[0010]. **BRIEF DESCRIPTION OF THE DRAWINGS**

[0011]. Fig. 1 is a low-magnification photomicrograph showing the microstructure of an extruded tool blank made from tungsten alloy W- 26% Re – 0.28% Hf – 0.02% C.

[0012]. Fig. 2 is a high-magnification photomicrograph showing the microstructure of an extruded tool blank made from tungsten alloy W- 26% Re – 0.28% Hf – 0.02% C.

[0013]. For a better understanding of the present invention, together with other and further objects, advantages and capabilities thereof, reference is made to the following disclosure and appended claims in connection with the above-described drawings.

[0014]. **DETAILED DESCRIPTION OF THE INVENTION**

[0015]. Tungsten alloy tools of the present invention combine excellent high temperature wear resistance with good toughness. The toughness is believed to be improved by the additions of rhenium and the hafnium carbide is believed to add wear resistance and hot hardness.

[0016]. A tool, as is relevant to the present invention, is defined as at least one of: an instrument used or worked by hand or by machine; an implement for cutting, shaping, welding, drilling, scraping, and/or otherwise modifying a work-piece; and a cutting, shaping, welding, drilling, scraping, and/or otherwise modifying part associated with a machine. Examples of tools include, but are not limited to: friction stir weld tools, drill bits, milling cutters, shear blades, tool bits, piercing punches, hot tube draw mandrels, wire and tube draw dies, extrusion dies, mill rolls, flow forming tools, and blanking punches and dies.

[0017]. **EXAMPLE I**

[0018]. A tungsten alloy of nominal composition W- 26% Re – 0.28% Hf – 0.02% C was produced by consumable vacuum arc melting of an electrode consisting of tungsten bar, electron-beam melted rhenium slugs, hafnium wire and carbon yarn. An ingot of 75-mm diameter was formed, then hot extruded with a preheat temperature of 2000 °C to bar of 37 mm diameter. The extruded bar was machined to produce a tool for use in friction stir welding. The tool was used to

friction stir a length of 50 cm of stainless steel plate. The wear of the tool during the weld processing was less than 25 micrometers.

[0019]. The material may also be used as a surface layer on a lower cost tool substrate material to provide the benefits of the present invention while providing a lower cost tool than one made entirely of tungsten alloy. The tungsten alloys described above can be used as surface layers on various other materials, for example, metals, alloys, cermets, and ceramics. The tungsten alloy surface layer can be applied by plasma spray, high-intensity infrared fusion, etc. For application on materials with mismatched thermal characteristics and/or crystal lattices, buffer materials can be used, and/or graded structures can be used.

[0020]. Such uses can lower the overall cost of component fabrication because less expensive materials can be used as substrates, with the tungsten alloys as surface layers (including all forms thereof, such as coatings, laminates, for example) thereon to gain the benefit thereof at the point of exposure to oxidizers, corrosives, high wear, etc. at high temperatures.

[0021]. **EXAMPLE II**

[0022]. A tungsten alloy is prepared as described in Example I and coated onto an extrusion die by a conventional plasma spray method to form a tungsten alloy coated extrusion die.

[0023]. Moreover, a tungsten alloy tool may have a surface layer of another material thereon. Suitable surface layer materials include those that are harder and/or more wear resistant than the tungsten alloys. Examples of suitable surface layer materials include but are not limited to, alone or in any combination: boron carbide, hafnium carbide, titanium carbide, niobium carbide, tantalum carbide, zirconium carbide, boron nitride, hafnium nitride, titanium nitride, niobium nitride, tantalum nitride, zirconium nitride, aluminum oxide, and hafnium oxide.

[0024]. It follows that a tool having a tungsten alloy surface layer may have a further surface layer of another material thereon (as described hereinabove), with the tungsten alloy serving as an intermediate layer.

[0025]. While there has been shown and described what are at present considered the preferred embodiments of the invention, it will be obvious to those skilled in the art that various changes and modifications can be prepared therein without departing from the scope of the inventions defined by the appended claims.